BEFORE INDEPENDENT HEARING COMMISSIONERS
IN CHRISTCHURCH

TE MAHERE Ā-ROHE I TŪTOHUA MŌ TE TĀONE O ŌTAUTAHI

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of the hearing of submissions on Plan Change 14 (Housing and Business Choice) to the Christchurch District Plan

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STATEMENT OF PRIMARY EVIDENCE OF JOHN BENJAMIN LILEY ON BEHALF OF CHRISTCHURCH CITY COUNCIL

ATMOSPHERIC SCIENCE

QUALIFYING MATTER – SUNLIGHT ACCESS

Dated: 11 August 2023

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EXECUTIVE SUMMARY

1. My full name is **John Benjamin Liley**. I am employed as an atmospheric scientist by the National Institute of Water & Atmospheric Research (**NIWA**).

2. I have prepared this statement of evidence on behalf of the Christchurch City Council (the **Council**) in respect of technical matters related to the Sunlight Access Qualifying Matter (**Sunlight Access QM**) proposed as part of Plan Change 14 to the Christchurch District Plan (the **District Plan**; **PC14**).

3. I was engaged by the Council to calculate both the reduction in direct sun time and the loss of solar heating from adjacent buildings under the Medium Density Residential Standards (**MDRS**) and under the proposed Sunlight Access QM.

4. I have considered the proposed recession planes and assessed their effect on the solar energy incident on a building in the shade of other buildings compliant with either the MDRS or other height enabling provisions in PC14.

5. As a specialist in the solar energy resources of Aotearoa, I had developed Solarview; software to estimate available solar energy on surfaces of arbitrary tilt and bearing anywhere in New Zealand. In the present context, for the Council, I added the capability to include structures in front of the physical landscape portrayed by Solarview, and I have used that product to compare the effect of the MDRS and other development-enabling provisions in Auckland and Christchurch on shading of a building surface or window by adjacent buildings.

6. In my view, having compared the impact of recession planes in Auckland and Christchurch under the MRDS and other height enabling provisions through the use of this software, the MDRS results in greater shading loss in Christchurch than in Auckland.

7. In my opinion, my analysis shows that the modifications proposed to the recession planes via the Sunlight Access QM will reduce the loss of sunshine hours and solar energy losses in Christchurch such that the losses are comparable to the losses that will be experienced under the MDRS recession planes in Auckland for the likely orientations of shaded and shading buildings.

8. My evidence does not respond to submissions and further submissions concerning the Sunlight Access QM but rather, any such submissions are addressed in the evidence of other Council witnesses who have been informed by my analysis.

INTRODUCTION

9. I, **John Benjamin Liley**, known as Ben Liley, am an atmospheric scientist employed by NIWA. I am based at NIWA's atmospheric research station at Lauder in Central Otago.

10. As a specialist in the solar energy resources of Aotearoa, I developed Solarview; software to estimate available solar energy on surfaces of arbitrary tilt and bearing anywhere in New Zealand. That software has been served for the last 15 years on NIWA's web pages (http://solarview.niwa.co.nz), where it is widely used. In the present context, for the Council, I added the capability to include structures in front of the physical landscape portrayed by Solarview, and I have used that product to compare the effect of recession planes proposed under the MDRS and other height enabling provisions in both Auckland and Christchurch.

11. In preparing this evidence I have:

    (a) Reviewed relevant climate parameters in the five cities to which the MDRS applies.

    (b) Reviewed the effect of latitude on solar angles as they pertain to the MDRS, and the relative importance of solar energy in the four North Island cities and in Christchurch.

    (c) Used Solarview as modified to include putative structures that implement the higher residential density intended within MDRS. The simulations included both the specifications of MDRS and modifications proposed in the Sunlight Access QM.

    (d) Reviewed the section 32 report(s) for PC14 relating to the Sunlight Access QM including the relevant appendices1.

[1] Section 32 Report (Qualifying Matters) Part 3 Plan-Change-14-HBC-NOTIFICATION-Section-32-Qualifying-Matters-Part-3-15-March.pdf (ccc.govt.nz), Appendix 34 – section 77L evaluation of Sunlight Access QM PC14-s77-Evaluation-of-Sunlight-Access-Qualifying-Matter.pdf (ccc.govt.nz), Appendix 35 – 'Technical Report – Residential Recession Planes in Christchurch' PC14-QM-Sunlight-Access-Urban-Design-Rpt.pdf (ccc.govt.nz)

(e) Reviewed the proposed recession plane standards in sub-part 6.1A of PC14; and

(f) Reviewed the relevant extracts from the draft section 42A report concerning the Sunlight Access QM prepared by Ike Kleynbos.

12. I am authorised to provide this evidence on behalf of the Council.

QUALIFICATIONS AND EXPERIENCE

13. I hold the qualifications of B.Sc.(Hons)(1) in Mathematics (Auckland), Dip.Hons. in Physics (Canterbury), and M.Sc. in Mathematics (Canterbury).

14. I have worked in scientific research for 38 years, initially for the Ministry of Agriculture and Fisheries, then for the NZ Meteorological Service, and now for NIWA since its inception in 1992. I specialise in solar radiation research, especially UV and its health effects, and in broadband solar radiation including radiative balance and solar energy applications. Over the last 15 years I have developed and maintained the files used to represent different climate zones in New Zealand (18 zones) and Australia (83 zones) in software to simulate energy performance of buildings, both residential and commercial.

15. I am a member of the Meteorological Society of New Zealand.

CODE OF CONDUCT

16. While this is a Council hearing, I have read the Code of Conduct for Expert Witnesses (contained in the 2023 Practice Note) and agree to comply with it. Except where I state I rely on the evidence of another person, I confirm that the issues addressed in this statement of evidence are within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from my expressed opinions.

SCOPE OF EVIDENCE

17. My statement of evidence:

(a) Considers the relevant climate parameters in the five cities to which the MDRS applies, including Christchurch, and assesses the effect of latitude on solar angles as they pertain to the MDRS and the relative importance of solar energy in the four North Island cities and in Christchurch.

(b) Compares the impact of the MDRS and other height enabling provisions on sunshine hours and on the solar energy incident of a building in the shade of other buildings in Auckland and Christchurch.

(c) Assesses the impact of the MDRS and other height enabling provisions as modified by the proposed Sunlight Access QM on sunshine hours and on the solar energy incident of a building in the shade of other buildings in Christchurch.

18. I address each of these points in my evidence below.

LATITUDINAL DIFFERENCES BETWEEN CITIES SUBJECT TO MDRS AND IMPACT ON SUNLIGHT ACCESS

19. Five major cities are obliged to give effect to MDRS. The MDRS set certain conditions as applicable nationwide, but their effect on sunlight access will vary across the country, especially with latitude.

20. At any given time of year, outside the tropics, the sun will rise lower in the sky by the difference in latitude, as illustrated in **Table 1**.

Table 1. Sun angles for Tier 1 councils affected by MDRS

City	Latitude °S	Peak Solar Elevation Summer	Peak Solar Elevation Winter
Auckland	37.0	76.4	29.6
Tauranga	37.7	75.7	28.9
Hamilton	37.8	75.6	28.8
Wellington	41.4	72.0	25.2
Christchurch	43.5	69.9	23.1

21. Thus, at solar noon in Auckland in midsummer the solar elevation peaks at 76.4°, whereas in Christchurch it is 69.9°; 6.5° lower. In midwinter the figures are 29.6° and 23.1°, and the sun is more readily blocked by taller buildings in Christchurch than in Auckland. The wintertime comparison is more relevant to the MDRS both because direct sunlight is more likely to be blocked at low solar elevation and because passive solar heating is more valued in winter.

22. The other large factor affecting sunlight access is of course cloudiness, and this also varies between centres, as shown in **Table 2**. Climate normals for 1991-2020 for representative sites in the five cities above show as expected

that Tauranga has the highest number of sunshine hours, but Auckland and Christchurch are the next highest, and comparable.

Table 2. Sunshine hours for MDRS cities (1991-2020 Normals)

City	Sunshine Hours		
	June	December	Annual
Auckland	126	202	2120
Tauranga	134	241	2400
Hamilton	120	212	2030
Wellington	101	218	2090
Christchurch	115	215	2130

23. As to variation within a city, there is obviously an effect of topography within Wellington, and to a lesser extent Auckland and Tauranga. Hamilton and Christchurch, excluding the hill suburbs of the latter, have minimal topography to influence aspect or cloud formation.

24. The region of Christchurch to which MDRS is applicable lies between latitudes of 43.35° and 43.60° S. Over that 0.25 degrees of latitude at any given time the solar elevation differs by the same angle, which is about half the observed solar diameter. This difference is less than the precision by which any of the calculations below might be applied, so they are equally applicable to anywhere within the Christchurch City.

25. There are few ground-based instruments (sunshine hour recorders, or pyranometers that measure solar flux) within Christchurch to assess any other source of variation in cloudiness, such as from proximity to the coast or the hills, but our past analysis of satellite data suggest that there is no significant variation in solar flux or sunshine hours across the level area of the City. Any consideration of the effects of shading by adjacent buildings will apply pari passu across the City north of the hills.

26. A tool on NIWA's web pages can be used to calculate available solar energy, on surfaces of arbitrary tilt and bearing, anywhere in Aotearoa New Zealand (http://solarview.niwa.co.nz). It generates a plot as in **Figure 1** below, with more complete output provided in associated tables.

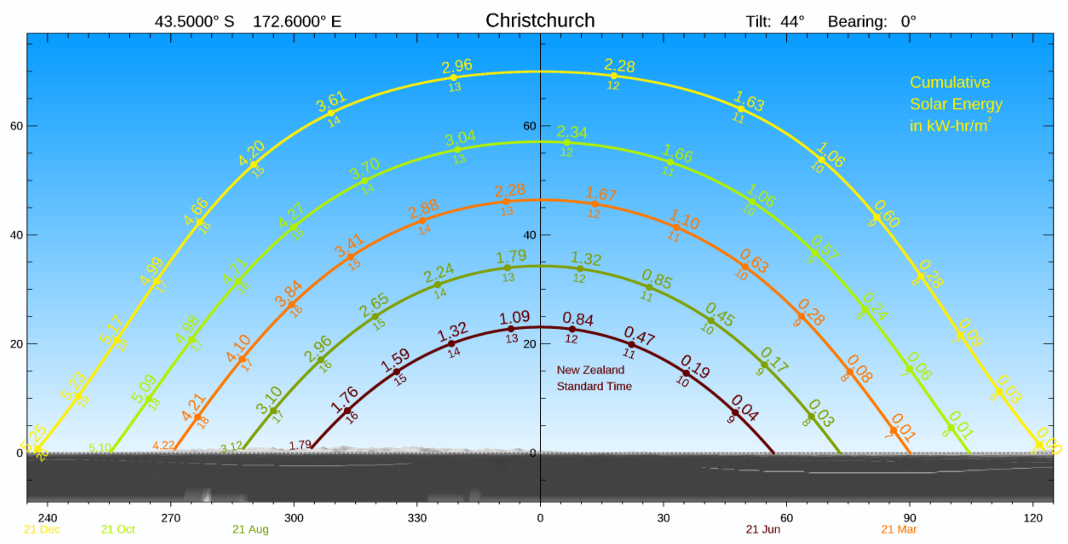


Figure 1. Example Solarview plot for Christchurch. Axes are in degrees of elevation and azimuth. Solar tracks are for the dates labelled in matching colours under the plot.

27. The plot shows, for any given location, the physical landscape looking northward as calculated from a digital elevation model. For Christchurch, the distant Southern Alps are visible, but they lie entirely below 1.4° of solar elevation, as can be seen from the axes in degrees of elevation and azimuth.

28. Superimposed on the landscape are the solar tracks for five specific days; the summer and winter solstices, autumn equinox, and two shoulder dates in spring. The tracks are labelled by hour (NZST), reading from right to left across the day. The smaller dots between hours that appear to make up solid lines are 0.5° wide, or about the size of the sun on this plot.

29. Above the solar tracks are the cumulative solar energy received by a solar panel of given tilt and bearing, averaged over 15 days either side of the labelled date. As in **Figure 1**, the default is to tilt north to latitude angle; often considered optimal for solar generation.

30. The calculation of incident solar energy is based on the geometry shown, including any horizon shading, though that is negligible for Christchurch on the Canterbury plain. To estimate available solar energy, the record of hourly irradiation (horizontal flux) from the nearest climate station is compared with model clear sky values to infer the separate diffuse and direct components of each hourly value, and these can then be used to compute flux on a surface of given tilt and bearing.

31. In this sense, the solar energy values combine the two effects discussed above, as they combine solar elevation with average cloud effects. For this reason, the Solarview tool serves as the basis for analysis in section Error! Reference source not found.3 below, where it is applied for vertical surfaces.

CLIMATIC DIFFERENCES BETWEEN CITIES SUBJECT TO MDRS AND IMPACT ON SUNLIGHT ACCESS

32. As well as the differences in solar energy flux onto walls or through windows, NZ cities differ in how much value their residents put on solar warmth. While that is subjective, several measures have been developed internationally to characterise heating or cooling requirements in different climates.

33. A usual criterion is the need to maintain a specified indoor temperature, typically 18 °C. The NIWA Climate Database (http://cliflo.niwa.co.nz) holds figures for heating degree days (**HDD**), calculated over months and years. For days when mean temperature, or just the mean of daily minimum and maximum, falls below 18 °C, the HDD is incremented by the deficit. For example, a day with a mean temperature of 12 °C adds 6 to HDD. Typical annual figures for the decade 2011-2020 are shown in **Table 3** for the five cities.

Table 3. Heating degree days for major NZ cities (2011-2020)

City	Heating Degree Days (18 °C)		
	Lowest	Highest	Mean
Auckland	922	1120	1020
Tauranga	1028	1270	1130
Hamilton	1345	2113	1530
Wellington	1610	1960	1740
Christchurch	2194	2519	2320

34. While there is obviously variation from year to year, it is apparent that heating requirements for Christchurch are about twice those for the northern North Island, with Wellington intermediate but closer to the other North Island values. A reasonable interpretation is that passive solar heating is about twice as valuable to residents in Christchurch.

35. The detailed calculation of how solar flux affects indoor air temperatures is a specialist craft. There is expertise and experience in NZ at VUW School

of Architecture, MBIE Building System Performance, BRANZ, Kāinga Ora, and elsewhere, with tools for simulating the response of prescribed building designs to different climates. Though that expertise is not duplicated within NIWA, we have characterised NZ climates and developed the data files for use in such simulations.

36. For the present context, the question is not how a given building will perform, but what will be the effect of shading from an adjacent building compliant either with the MDRS or with PC14. For that, we consider just changes in hours of direct sun and in incident solar energy.

COMPARISON OF IMPACT OF MDRS ON SUNLIGHT ACCESS IN AUCKLAND AND CHRISTCHURCH

Overview

37. Having established above that the latitude and climate of Christchurch are characteristics of the whole city but clearly distinct from North Island cities, a direct comparative assessment has been undertaken to evaluate the difference in the impacts on sunlight access of applying the MDRS and other development-enabling provisions in Christchurch and Auckland.

38. The methodology for this comparative assessment is described below.

Sunlight Access modelling

39. To calculate both the reduction in direct sun time and the loss of solar heating from adjacent buildings, I use the Solarview tool as introduced in Section 1. Rather than the on-line version, I apply a development version modified to include defined structures as represented by a set of opaque rectangles.

40. Under their proposed Sunlight Access QM, the Council requested modelling of the level of solar access to the first storey of a building through:

    (a) Calculating the amount of sunlight hours / radiation received on a ground floor window of a standard house at different times of the year and the total sun hours or radiant energy received over a year.

    (b) Models rotated in increments of 30 degrees from North, but allowing for approximate diurnal symmetry.

41. For this purpose, a model building is assumed to be three storeys high, and we consider its shading effect on the lower floors of an adjacent building of the same design. That is calculated from Solarview as the flux on a window or the ground surface (for outdoor living).

42. The assumed structure is taken from initial work by the Council as illustrated in **Figure 2**.

Figure 2. Assumed MDRS/QM-compliant design. This design was developed by CCC to illustrate how the objectives of MDRS could be achieved within CCC Plan Change 14

43. The relative positions of the buildings are as shown in **Figure 3**, and the calculations of reduced sunlight are for the coloured unit. The same structures and layout are then rotated to simulate alignment with varying street orientation, as in **Figure 4**.

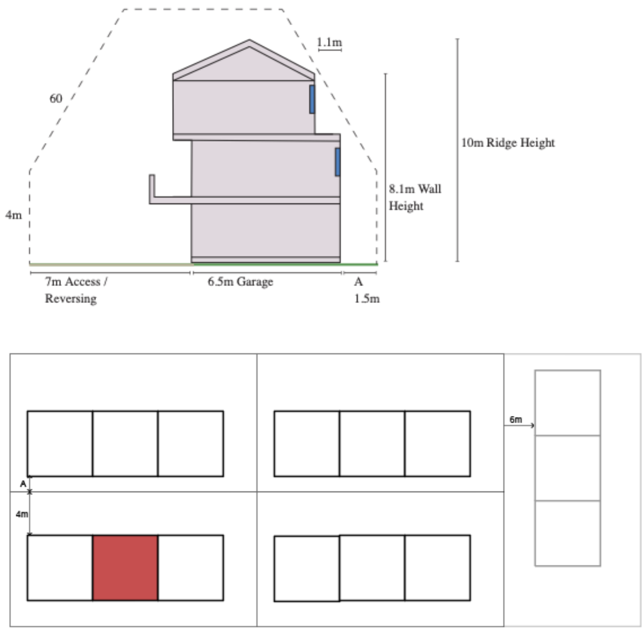


Figure 3. Assumed MDRS/QM-compliant dimensions and layout. Calculations of shading are for the unit shown in red. Distance 'A' varies to give the required recession planes. From 3 metres height angles of 50°, 55°, and 60° are achieved with A = 3.4 m, 2.6 m, and 2 m respectively.

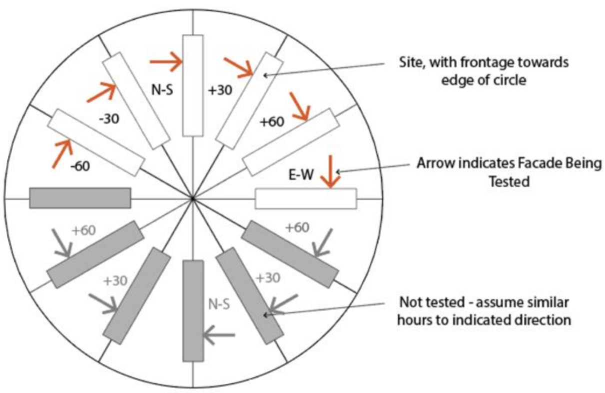


Figure 4. Building orientations considered. The layout of buildings shown in Figure 3 is rotated through a series of 30° steps to allow for different street directions.

44. A range of recession plane models have been considered, informing the PC14 as notified. The suggested angles are shown in **Figure 5**.

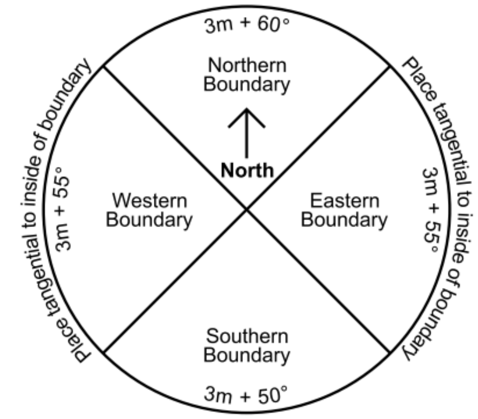


Figure 5. Proposed Plan Change 14 recession angles. The different recession planes are achieved by offsets from the boundary as shown in Figure 3.

45. In the plots that follow, the representation of the buildings is rather simplistic, and it perhaps requires some imagination to envisage the neighbouring structure involved. The range of azimuth angles has been reduced from the 250° default of Solarview, as in **Figure 1**, to just the 180° visible from the putative window at 1 metre height above ground.

46. The charts allow the comparison of variation in built form scenarios at different locations. Total solar energy received can be read from the figures shown on the plot, whilst sunlight hours can be estimated from the plot itself (where the line is shown against the sky).

47. The solar flux in watts per square metre (W m-2) is the rate of incident energy, whether for passive solar heating or for partial capture (e.g., 20%) by solar panels. The direct sunlight on a panel at right angles to a beam gives a flux of around 1000 W m-2 for sun well above the horizon, so a cumulative energy flux of 1 kW-hour m-2 is also called a ‘peak sun hour’. Thus, from **Figure 1**, Christchurch typically receives just over five peak sun hours in mid-summer, and just under two in winter.

48. While this is not the same measure as the duration of direct (‘beam’) solar radiation, which is reported as ‘hours of bright sunshine’, the two are obviously related, and both are higher on clear days. Either may be relevant to the perspective cited in Section 2; that solar heating may have a higher subjective value to those in colder southern climates. As well as the greater warmth from direct sunlight, bright sunlight certainly effects mood, especially at colder times of year. Against that, bright sunshine may be cheering even when observed from within shade.

49. Overall, the use of energy flux, with its possible interpretation as peak sun hours, is readily justified. It is the relevant measure for both passive solar heating and photovoltaic generation, and thus is the standard input to calculations of energy balance in the built environment. For these reasons it is the basis of all the analyses below.

Impact of MDRS on sunlight access in Auckland

50. The Solarview model has been used to assess the impact of applying a MDRS-enabled development scenario in Auckland on sunlight access such that this can be compared with the impacts on sunlight access in Christchurch under the MDRS.

51. The first such scenario is shown in **Figure 6**, which demonstrates the view, from a ground-floor window facing north, of adjacent buildings as defined in **Figure 3**. The buildings are superimposed on the solar path for five dates from winter to summer. The orientation, and the location of the viewpoint, are shown in the small figure to the right of the caption.

North-facing Site – buildings oriented E – W

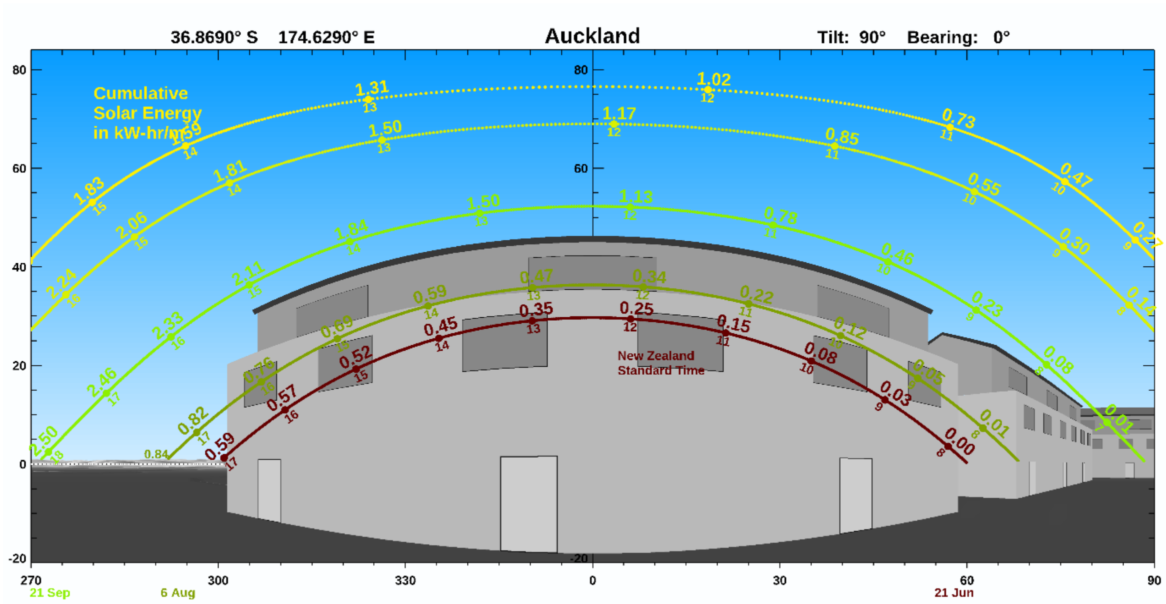
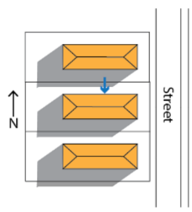


Figure 6. View of adjacent buildings from north-facing window. As in Figure 1, but now reduced by shading from neighbouring buildings as allowed by MDRS. Figures above curves show average incident solar energy accumulated over Auckland days on dates shown below the axis, plus 6 Nov and 21 Dec.



52. The apparent distortion of the buildings is an inevitable consequence of the 180°-wide view, which necessitates a cylindrical projection rather than the

more familiar rectilinear projection of photographs with a narrower field of view. The effect is the same as taking a 'panorama' photograph, which will similarly distort non-vertical lines into curves.

53. The dates of the solar tracks represent the winter solstice (21 June), the spring equinox (21 September), and the summer solstice (21 December), plus the mid-points between those dates (6 August and 6 November) . For reasons of approximate symmetry, we do not include the corresponding dates in the first half of the year.

54. The cumulative solar energy shown on the solar arcs is that which is received on the viewing point with buildings as shown. It includes diffuse light, as in shade. For this reason, the cumulative solar energy continues to increase, albeit slowly, when the sun would be obscured by the building.

55. All of the calculations are averaged over the entire data record at the respective climate stations – 17 years for Auckland and 20 for Christchurch. In this respect, they represent average cloud conditions. Thus, the reduction in solar energy is less than it would be under clear skies from direct radiation. Against that, the diffuse light is almost always greater when cloud is present, as most cloud is brighter, and produces greater energy flux, than blue sky. Only under heavily overcast conditions with dark cloud is the diffuse component of radiation less than on a clear day.

56. In Error! Reference source not found.~~**Figure 6**~~ and all such plots on the following pages, the numbers at the left-hand end of the curves show the average solar energy accumulated over the respective day as affected by shading from the adjacent buildings.

57. The figures on the next two pages (**Figures 7 – 13**) show the progression as both the affected building and the shading building(s) are rotated to the west by increments of 30°, corresponding to different street orientations parallel to the long axis of the buildings.

Site facing 30° West of North – Buildings N – S + 60°

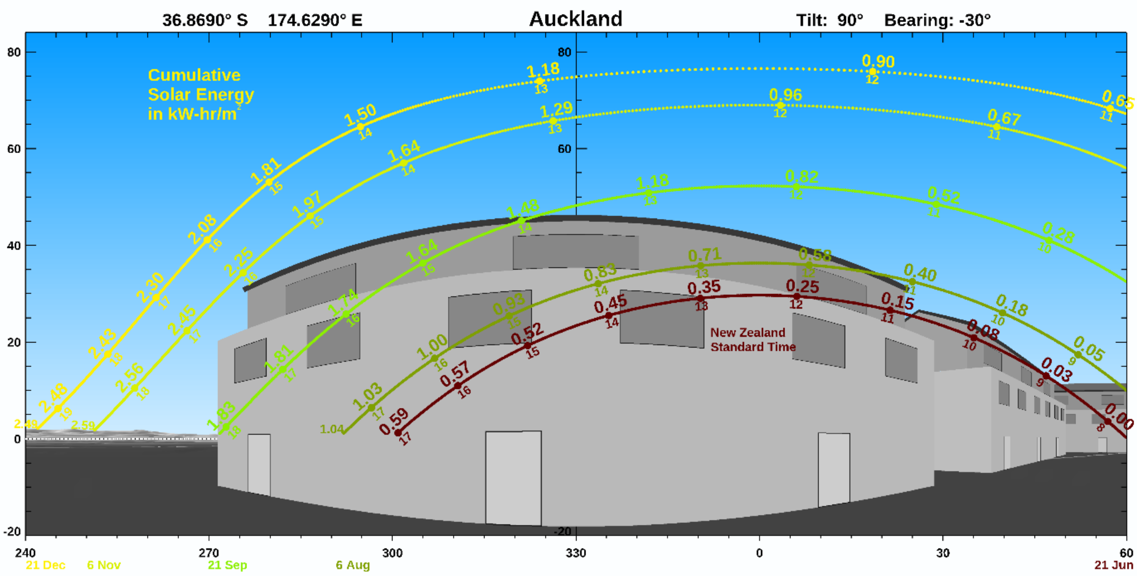
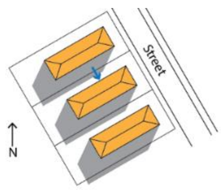


Figure 7. **View of adjacent buildings from window facing 30° west of north.** As in Error! Reference source not found.~~Figure 6~~, but now with both affected and shading building rotated 30° to the west.



Site facing 60° West of North – Buildings N-S + 30°

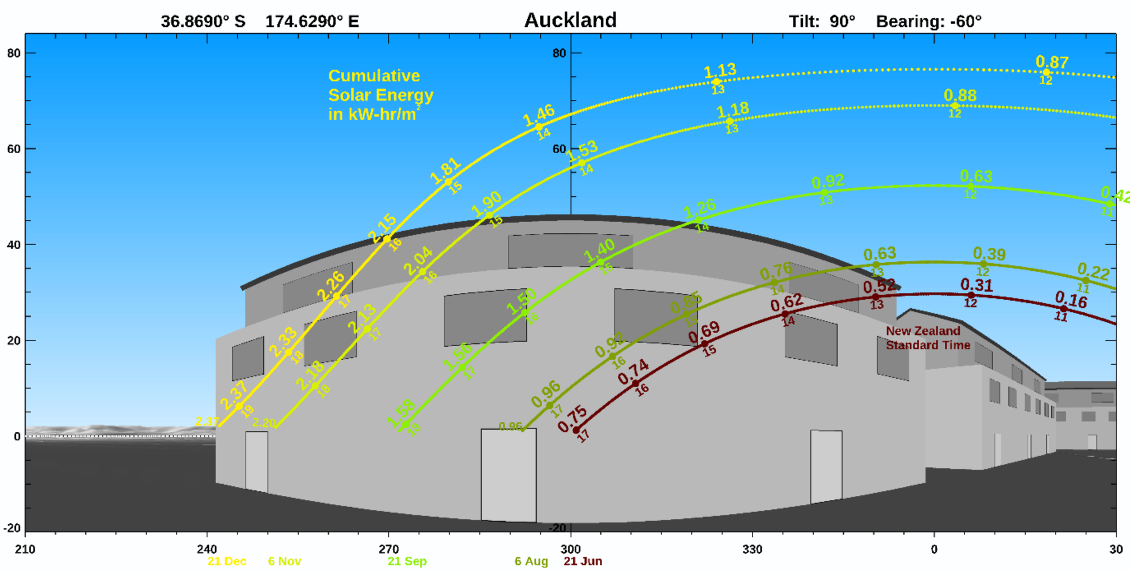
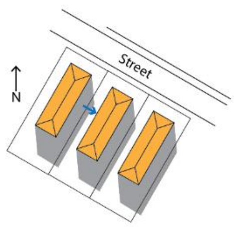
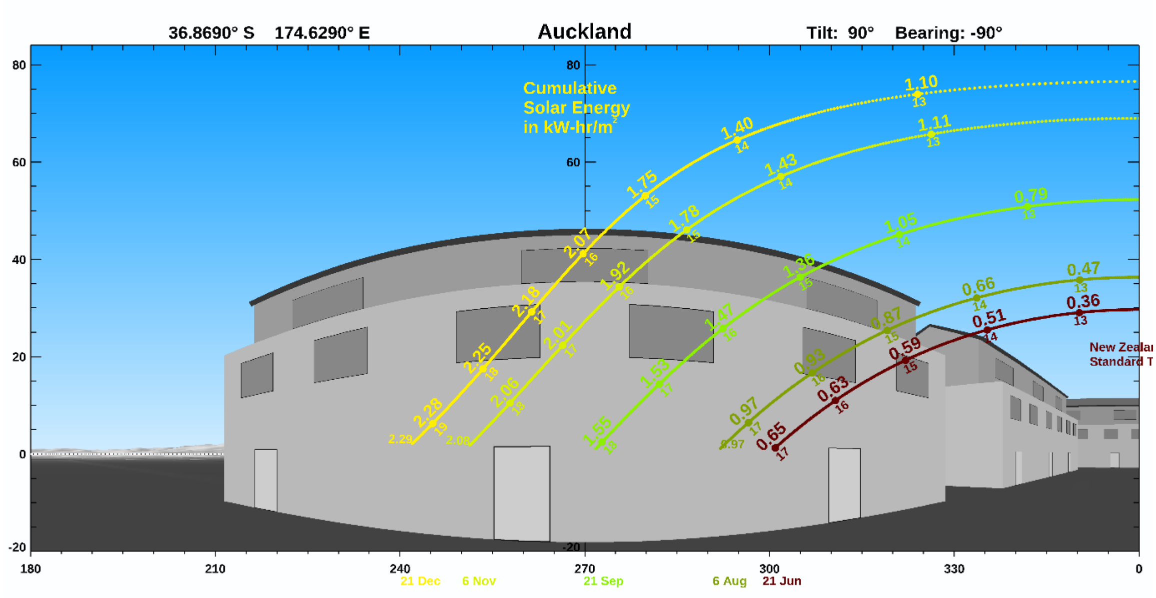


Figure 8. **View of adjacent buildings from window facing 60° west of north.** As in Figure 7, but rotated 30° further to the west.



West-facing Site – Buildings Oriented N-S



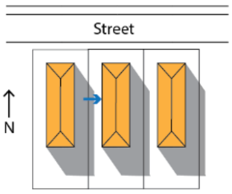


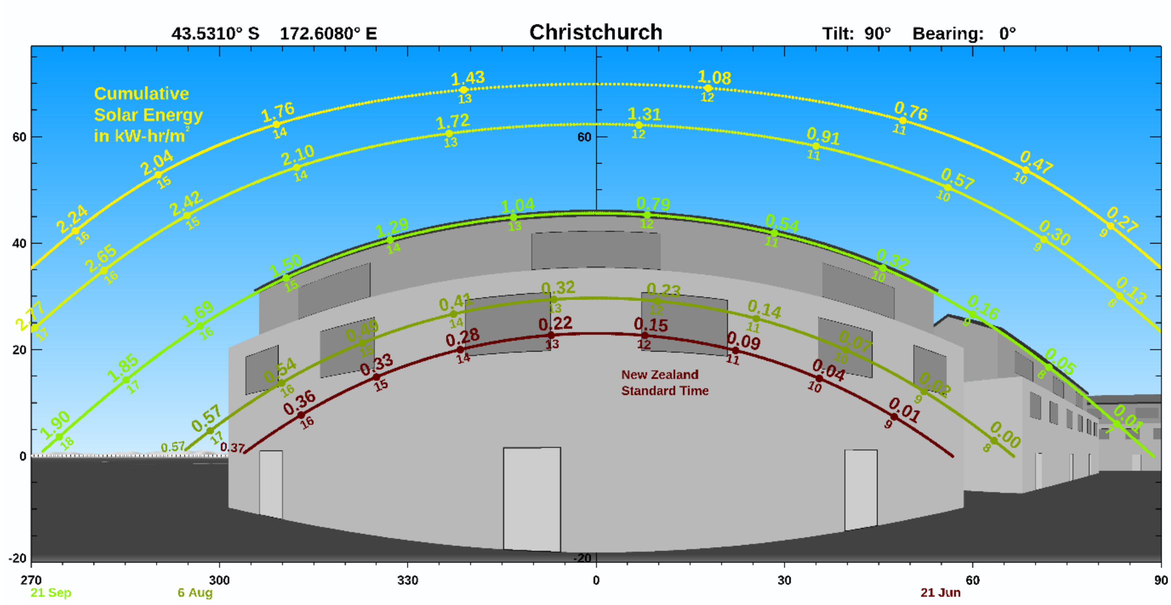
Figure 9. View of adjacent buildings from west-facing window, for N-S street frontage.

Impact of MDRS on sunlight access in Christchurch

58. The Solarview model has been used to assess the impact of applying a MDRS enabled development scenario in Christchurch on sunlight access such that this can be compared with the impacts on sunlight access in Auckland under the MDRS.

59. For ease of comparison, on the following pages the upper figure shows the effect of applying MDRS recession planes, while the lower figure shows the effect of the recession planes proposed for Christchurch.

North-facing Site – Buildings oriented E-W – MDRS



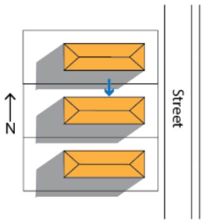
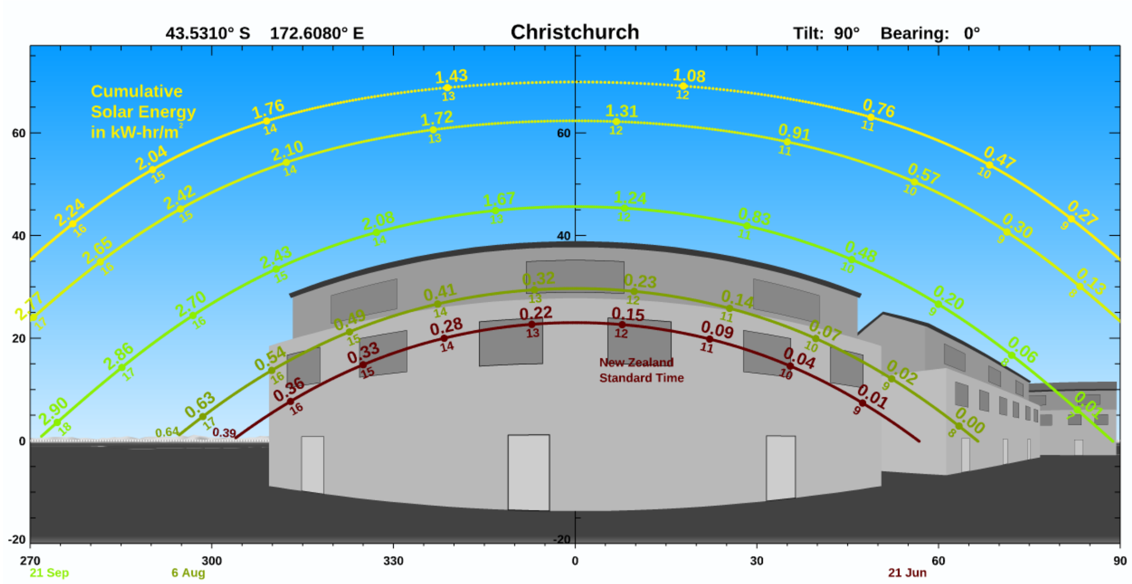


Figure 10. View of adjacent buildings from north-facing window, for E-W street frontage - MDRS. As in Error! Reference source not found.Figure 6, but now for Christchurch. In Auckland for this orientation under MDRS, the sun is 6° above the building at the spring equinox, but in Christchurch under MDRS it is obscured.

North-facing Site – Buildings oriented E-W – Recession plane at 3 m and 50°



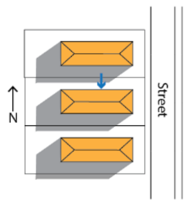
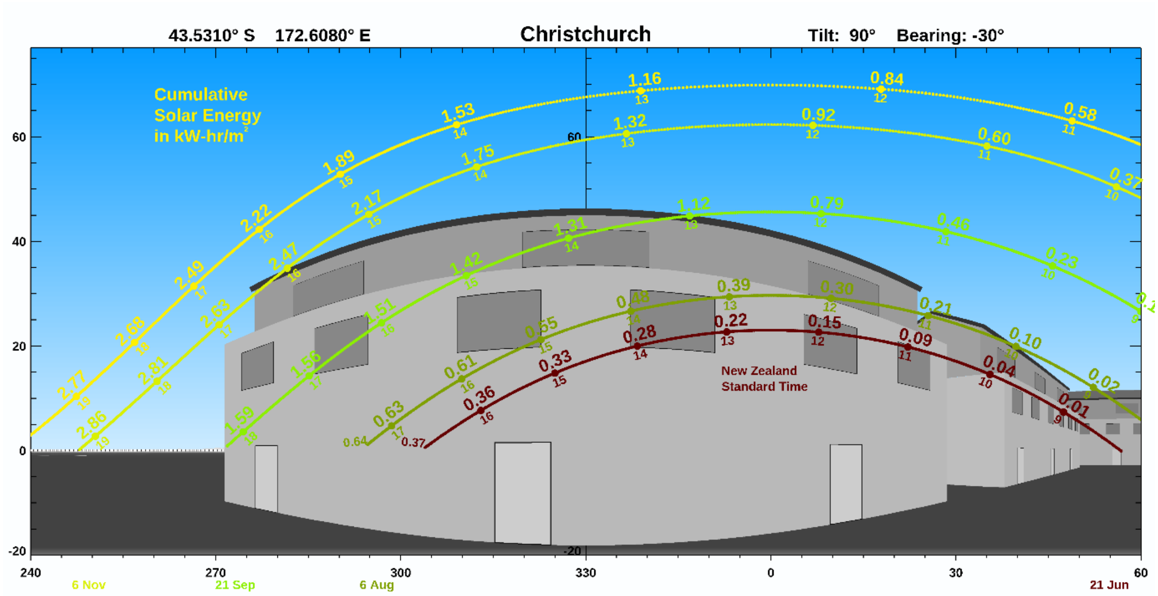


Figure 11. View of adjacent buildings from north-facing window, for E-W street frontage - QM. As in Figure 10, but with modified settings as proposed by the Council and shown in Figure 5. With the recession planes as defined, the sun is 6° above the adjacent roof line at the spring equinox, as in Auckland under MDRS.

Site facing 30° West of North – Buildings N-S + 60° – MDRS



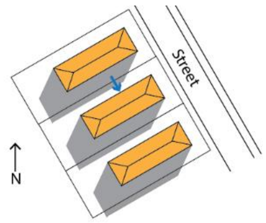
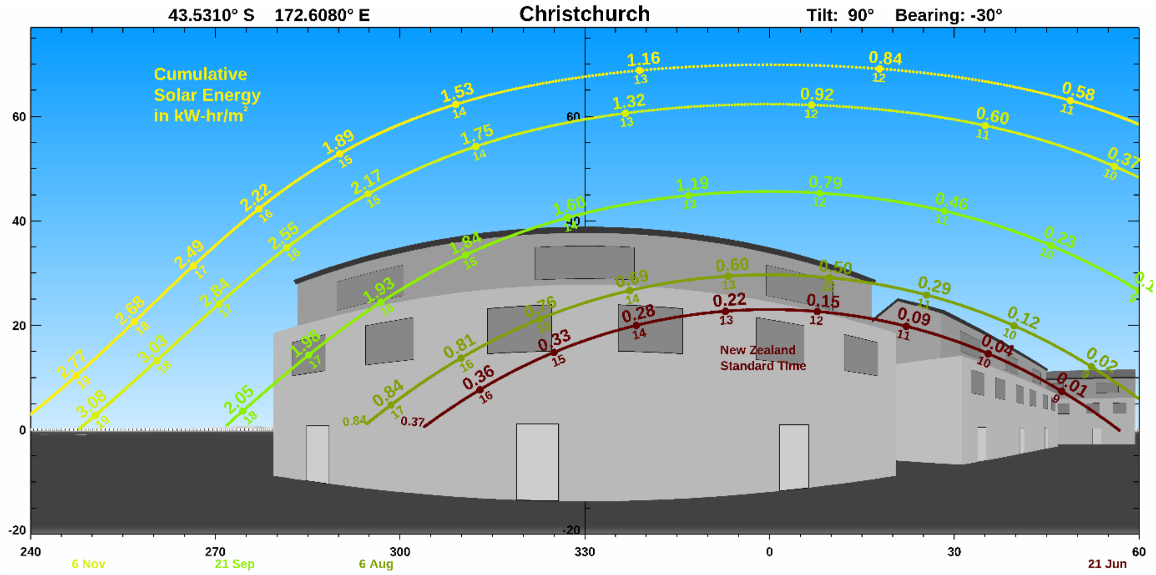


Figure 12. View of adjacent buildings from window facing 30° west of north --MDRS. As in Figure 10, but rotated 30° to the west. Compared with Auckland, the Christchurch setting loses the sun an hour earlier and the equinox, and almost entirely in August.

Site facing 30° West of North – Buildings N-S + 60° – Recession plane at 3 m, 50°



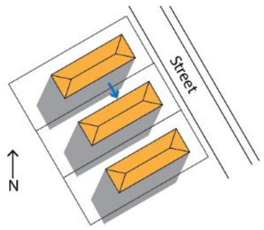
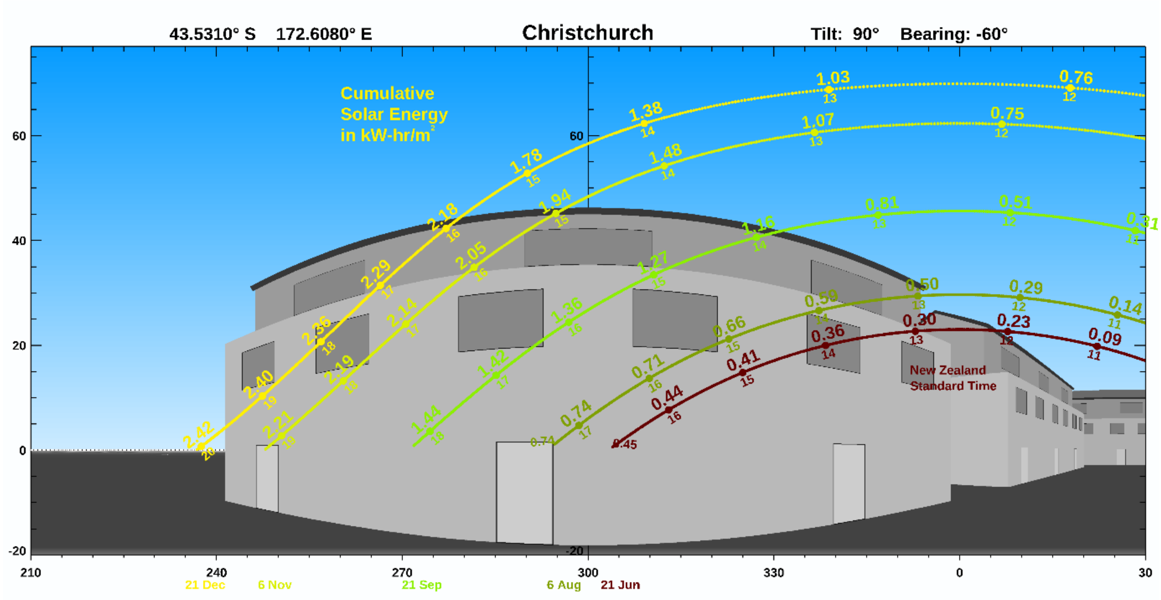


Figure 13. View of adjacent buildings from window facing 30° west of north - QM. The orientation is the same as Figure 12, but with modified settings as proposed by the Council and shown in Figure 5. As in the previous orientation, the proposed recession plane restores

comparability of solar access in Christchurch to that of Auckland under MDRS.

Site facing 60° West of North – Buildings N-S + 30° – MDRS



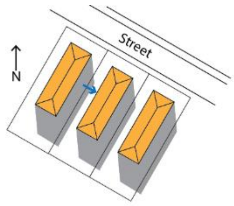
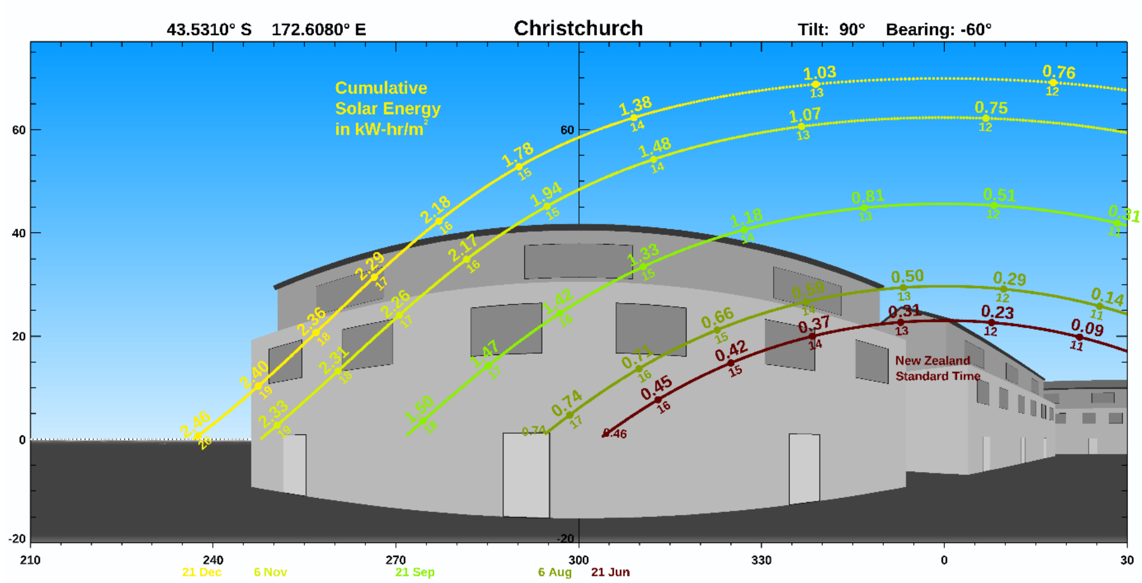


Figure 14. View of adjacent buildings from window facing 60° west of north – MDRS. As in Figure 12~~Figure 13~~, but with both affected and shading building rotated 30° further to the west. Comparison with Figure 8 shows that under MDRS, Christchurch loses sun an hour earlier than Auckland in winter months.

Site facing 60° West of North – Buildings N-S + 30° – Recession plane at 3 m, 55°



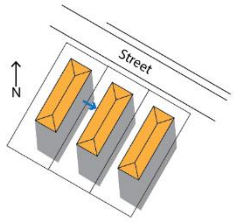
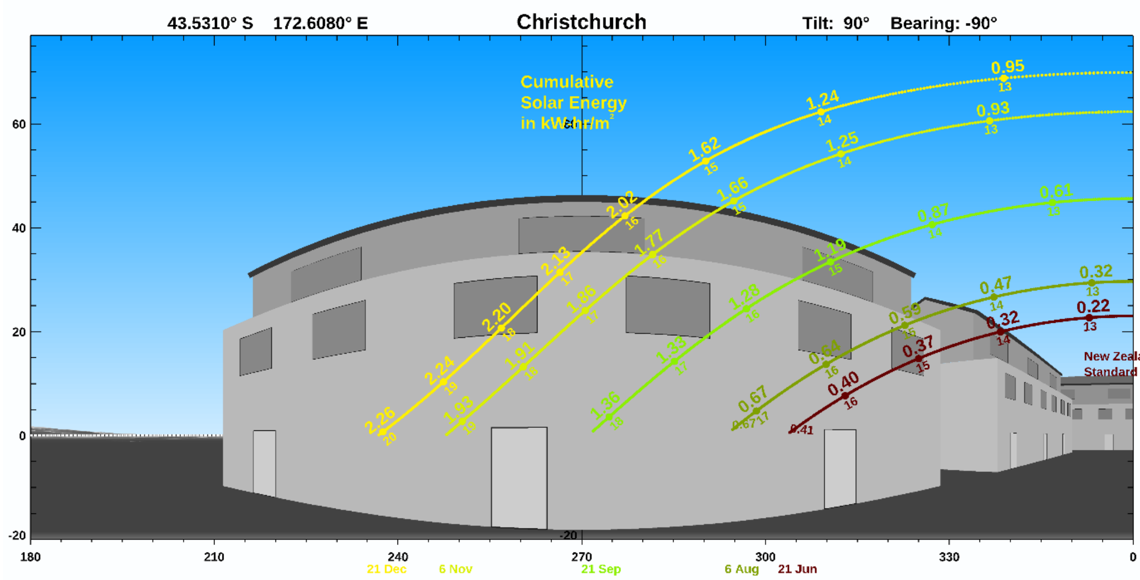


Figure 15. View of adjacent buildings from window facing 30° west of north - QM. As in Figure 14~~Figure 15~~, but with modified settings as proposed by the Council. As before, the duration of sunlight access in winter months is now closer to Auckland under MDRS, and solar energy loss is comparable.

West-facing Site – Buildings Oriented N-S – MDRS



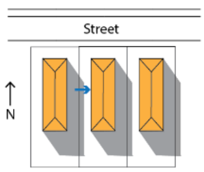
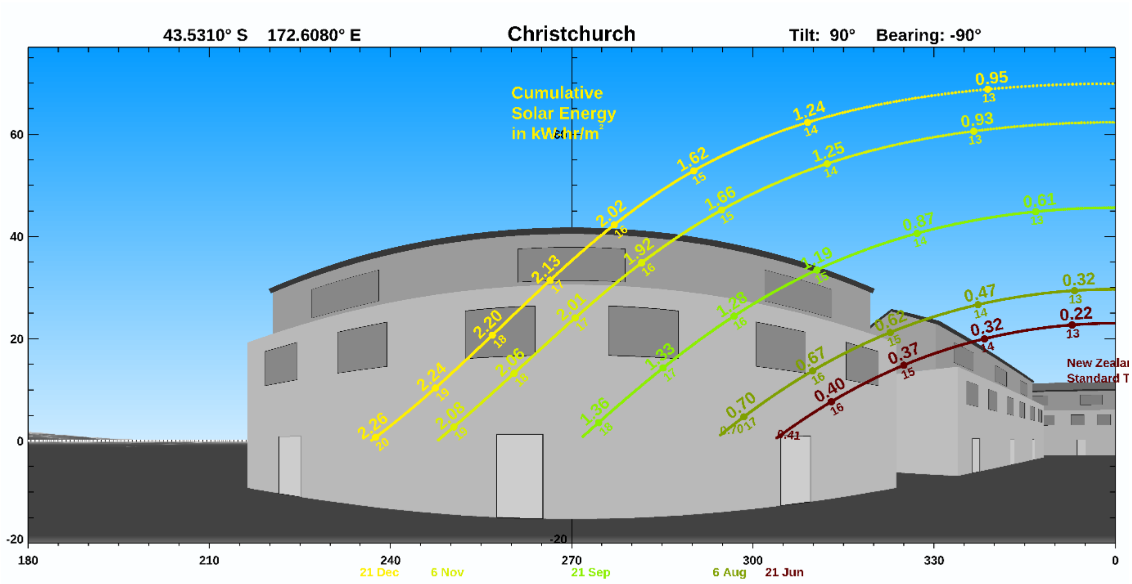


Figure 16. View of adjacent buildings from west-facing window, for N-S street frontage - MDRS. Comparison with Figure 9 for Auckland shows similar duration of sunlight access for this orientation, but the lower sun and shorter days in winter result in about 40% less solar energy in Christchurch relative to Auckland.

West-facing Site – Buildings Oriented N-S – Recession plane at 3 m and 55°



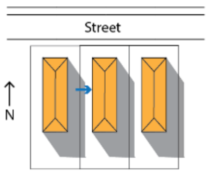


Figure 17. View of adjacent buildings from west-facing window, for N-S street frontage - QM. For this orientation, there is little change in sunlight duration, and no change in solar energy in winter because the window faces west so it is only illuminated by direct sun for 1-2 hours at very large incidence angles for those months.

Finding: of impact of MDRS between Auckland and Christchurch

60. The above figures are assembled into tables below for ease of comparison, in the same order of orientation as the plots, first for a bare site without any adjacent building and then for the scenario illustrated. The first five columns show the average values for the representative days, and the sixth column shows the average total over the year. The last column shows what is perhaps the most relevant factor; what fraction of annual average irradiance on the window is lost to shading by the adjacent buildings.

61. **Table 4** shows the results of shading under MDRS in Auckland, and **Table 5** shows the same for Christchurch.

Table 4. Effect on solar flux of adjacent buildings in Auckland under MDRS

Scenario	Average daily kW-h/m²					Annual	Shading
	21 Jun	6 Aug	21 Sep	6 Nov	21 Dec	kW-h/m²	loss
AK_E-W_bare	2.06	2.37	2.62	2.40	2.23	893.7	0.00%
AK_E-W_4m60	0.59	0.84	2.50	2.40	2.23	646.6	27.65%
AK_+60_bare	1.84	2.11	2.55	2.61	2.49	883.4	0.01%

AK_+60_4m60	0.59	1.04	1.83	2.59	2.49	649.9	26.44%
AK_+30_bare	1.39	1.71	2.41	2.79	2.77	842.9	0.09%
AK_+30_4m60	0.75	0.96	1.59	2.20	2.37	585.0	30.66%
AK_N-S_bare	0.99	1.31	2.13	2.76	2.84	759.8	0.15%
AK_N-S_4m60	0.65	0.98	1.55	2.08	2.29	551.0	27.59%

Table 5. Effect on solar flux of adjacent buildings in Christchurch under MDRS

Scenario	Average daily kW-h/m^2					Annual	Shading
	21 Jun	6 Aug	21 Sep	6 Nov	21 Dec	kW-h/m^2	loss
CH_E-W_bare	1.75	2.24	2.97	2.85	2.49	939.8	0.00%
CH_E-W_4m60	0.37	0.57	1.90	2.85	2.49	620.5	33.97%
CH_+60_bare	1.54	2.01	2.84	3.08	2.79	929.0	0.00%
CH_+60_4m60	0.37	0.64	1.59	2.86	2.79	608.8	34.46%
CH_+30_bare	1.07	1.53	2.53	3.21	3.12	858.4	0.00%
CH_+30_4m60	0.45	0.74	1.44	2.22	2.42	526.1	38.71%
CH_N-S_bare	0.68	1.06	2.07	3.03	3.14	735.0	0.00%
CH_N-S_4m60	0.41	0.67	1.36	1.94	2.26	484.6	34.07%

62. As is apparent from the plots, these tables show that the same MDRS values result in greater shading loss in Christchurch than in Auckland, by 6-8% for the different orientations. In round figures, losses of approximately 28%, 26%, 31%, and 28%, in Auckland become losses of 34%, 34%, 39%, and 34% in Christchurch.

IMPACT OF MDRS UNDER THE PROPOSED SUNLIGHT ACCESS QM ON SUNLIGHT ACCESS IN CHRISTCHURCH

63. As above, I have determined that the loss of solar heating from shading of buildings under the MDRS in Christchurch will be greater than the losses in Auckland for the same configurations. Having established that there are latitude, climate and sunlight access differences between Auckland and Christchurch, the Council proposes to adopt modified MDRS standards via a Sunlight Access QM across all relevant residential zones in Christchurch.

64. I understand that the objective of the Sunlight Access QM is to achieve an equitable outcome to sunlight access when compared to the Auckland context and to still readily enable three storey developments across relevant residential zones (subject to any other applicable QMs).

65. The proposed Sunlight Access QM seeks to adjust the recession plane controls to achieve a more comparable sunlight access outcome, whilst also delivering three storeys as shown in **Table 6**.

Table 6. Comparison of recession plane controls under MDRS and Sunlight Access QM

Measure	MDRS	Proposed Sunlight Access QM
Height	From 4 m above ground level	From 3 m above ground level
Northern boundary angle	60º	60º
Southern boundary angle	60º	50º
East-west boundary angle	60º	55º

Table 7. Table 7 shows the effect of the amendments to the recession planes under the proposed Sunlight Access the QM. Effect on solar flux of adjacent buildings in Christchurch under QM

Scenario	Average daily kW-h/m²					Annual	Shading
	21 Jun	6 Aug	21 Sep	6 Nov	21 Dec	kW-h/m²	loss
CH_E-W_bare	1.75	2.24	2.97	2.85	2.49	939.8	0.00%
CH_E-W_3m50	0.39	0.64	2.91	2.85	2.49	691.2	26.45%
CH_+60_bare	1.54	2.01	2.84	3.08	2.79	929.0	0.00%
CH_+60_3m50	0.37	0.84	2.06	3.08	2.79	686.9	26.06%
CH_+30_bare	1.07	1.53	2.53	3.21	3.12	858.4	0.00%
CH_+30_3m55	0.46	0.74	1.50	2.33	2.46	559.9	34.78%
CH_N-S_bare	0.68	1.06	2.07	3.03	3.14	735.0	0.00%
CH_N-S_3m55	0.41	0.71	1.36	2.08	2.26	501.5	31.77%

66. In round figures, the shading losses corresponding to the above are the 26%, 26%, 35%, and 32%, which are comparable to those for Auckland, (28%, 26%, 31%, and 28%, as above) under MDRS. In this respect, the proposed Sunlight Access QM appears to achieve its objective of allowing the intended densification of housing without the larger effect on shading.

CONCLUSION

67. In my opinion the latitude and climate of Christchurch are sufficiently uniform in Christchurch as to justify a single set of recession planes across the City. The latitude and climate differ from Auckland, and other North Island cities, to the extent that modification of recession planes is necessary

to achieve a comparable effect on sunlight access and solar heating of the intended densification of housing.

68. Through use of the enhanced Solarview software I have compared the impact of the MDRS and other development-enabling provisions under PC14 between Auckland and Christchurch. On the basis of my modelling described above, in my opinion the MDRS results in greater shading loss in Christchurch than in Auckland.

69. In my view, based on my modelling the modifications proposed via the Sunlight Access QM will reduce the loss of both sunshine hours and solar energy in Christchurch so that they are comparable to the losses that will be experienced under the MDRS recession planes in Auckland.

Date: 11 August 2023

Ben Liley